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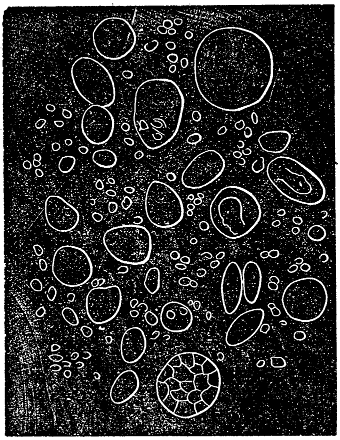
ABOUT STARCH.

BY PROFESSOR M. W. HARRINGTON.

II.

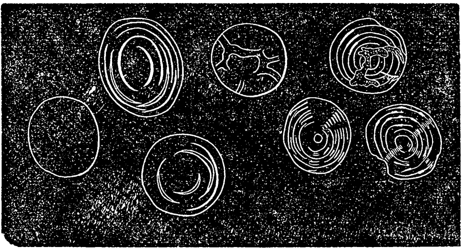
We have seen, in a former paper, that potato-starch consists of organized grains, each with a nucleus and around it a series of layers, each of which is denser than the one next within. This is the typical form of the grains of starch; but there are many variations on it. Many grains are without rings or nucleus or both. Sometimes the rings and nucleus can be brought out in these, by the action of reagents or by partial solution in any way. This is illustrated in the grains of wheat-starch. In Fig. 151 (taken from Planchon) we have the usual appearance of the starch of wheat. The largest grain at the bottom of the cut is a compound grain rare in wheat, characteristic of the starch of another group of cereals. In the typical grains we see no rings, only occasional incidental markings. In Fig. 152 (also from Planchon), we have wheat starch after the grain from which it was taken has germinated and solution has begun. In the starch-grains of many species, however, no rings can be

Fig. 151.



Wheat Starch.

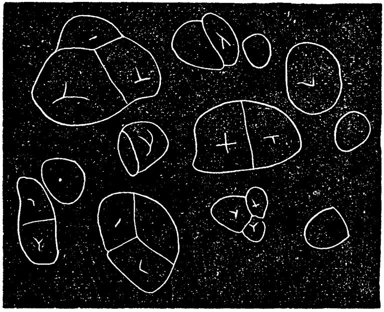
Fig. 152.



Wheat Starch.

made out, even with the aid of reagents. An illustration of this is the starch from the Colchicum-corm of the druggists (Fig. 153). Here we have a nucleus, often split into stellate shapes by drying, but no rings. Rings are not brought out by reagents, nor is there any cross with polarized light. In Fig. 154, which illustrates the starch of the root of aconite, we find neither nucleus nor rings.

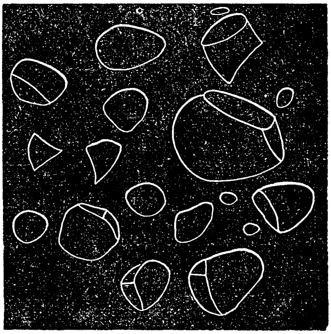
Fig. 153.



Colchicum Starch.

Starch is nourishment for the plant in a condition for preservation. We consequently find it in the thickened parts of plants, which serve as storehouses of nourishment. The starch of potato is in the tuber, a sort of thickened tip of an underground branch. In the colchicum the starch is in the corm or thickened base of the stem; in squills it is in the bulb. Rhizomes usually contain starch. That of the white water-lily is large and easily examined. The starch of the ginger rhizome is quite characteristic. That of the rhizome of sweet flag is very minute; the largest grains are hardly $\frac{1}{4000}$ of an inch in diameter. The slender rhizomes of the gold-thread contain a starch which is larger. The root often contains a large quantity of starch. The root of Stillingia of the shops is almost made up of starch. The stem of the sago-palms contains starch in immense quantities. The sago of commerce is derived from several species of them. Most barks of trees contain starch; though often in small quantities, sometimes the amount of starch is considerable in barks. Cinnamon contains a great deal. The starch may be confined to one layer of the bark, or, more abundant in one layer than in the others. In cascarilla bark, where the middle layer of the bark and the liber interdigitate, it is difficult to trace

Fig. 154.

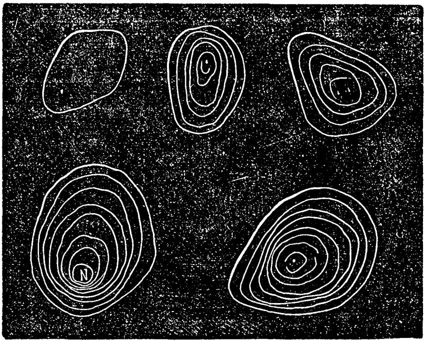


Aconite Starch.

out the line of division between the two until iodine is added. The middle layer contains much starch, the liber little. When the iodine is added the starch turns dark and the middle layer looks like a distinct black saw, with teeth projecting into the liber. In many fruits and seeds starch is found; in the embryo of the bean and pea and in the albumen of the nutmeg, corn, wheat and rice, it is very abundant.

The strangest situation, though, in which the writer ever found starch was in the centre of a nut-gall. In the middle of the hard commercial galls (obtained from *Quercus lusitanica* Webb, var. *infectoria*, from Asia Minor), is a little, hard, nut-like case of thick-walled, stony cells. This case is filled with cellular matter when first formed. The larva of the infesting insect is found within this case, and feeds on its cellular contents. If the gall is collected when the insect has already escaped, this little nut-like sphere is empty. If the gall is picked when immature, there is some matter left in the central nut, the greater or less quantity depending on the immaturity of the gall and of the enclosed insect. This matter within the central case, on which the insect feeds, contains starch. None of the rest of the gall-tissue contains the slightest trace of it. The grains (Fig. 155) are large and flat with a distinct nucleus, and, usually, distinct rings. They produce a marked cross with polarized light. They are so large that a cell seems to accommodate only a single grain of starch.

Fig. 155.



Starch of Nut Galls.

The presence of starch in this abnormal growth suggests some interesting questions. The starch is just where the parasitic *Cynips* will eat it and nowhere else. Starch is excellent food for many animals. We eat immense amounts of it with our cereals. The sparrows live on it. Doubtless the larva of the gall-fly finds it good food. On what principle of natural selection can we account for this food being placed so conveniently for it? So far as we can see, the *Cynips* does nothing but injury to the oak. Why should the oak provide it with choice food?

So far we have had in mind only vegetable starch. At one time it was thought that starch was peculiar to vegetables, but it has since been found in animals. In so undoubted an animal as man, starch has been found in organized granules in the brain. In appearance these grains of cerebral starch are very much like those of corn-starch. They are, however, softer.

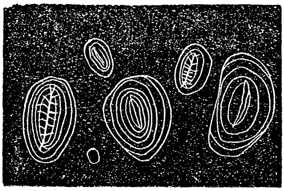
Starch is usually found in the parenchymatous tissue of plants. Exceptionally it occurs in the elongated, tapering cells. Pocklington records in the "London Pharmaceutical Journal," the constant occurrence of starch in the wood-cells of the ipecac root of the shops. A matter analogous to starch is found as secondary layers on the cell-walls of some seeds. Schleiden calls it *Amyloid*, and gives a short list of seeds in which he has found it. A probably identical substance is found in the seeds of the common peony. The peony seeds but meagrely here, but the seeds are used somewhat in medicine, and can be found in many shops, where they have been imported from Europe. The albumen of the seeds is made up of a compact parenchyma, with moderately thick-walled cells, filled with a granular matter. On the application of a weak solution of iodine, the contents of the cells are colored a bright yellow, but the cell-walls a pure blue. If they were of cellulose, the ordinary constituent of the cell-walls, they would not be colored blue by iodine until after the action of sulphuric acid.

Starch-grains are developed by gradual growth. The different stages can be seen in most starches, from the matured parts of plants. It can be seen still better in a nearly ripe grain of corn. Every stage of the following process can be seen there. A little cavity or vacuole is formed in the protoplasmic contents of a vitally active cell. A little matter is there deposited, and becomes the nucleus. The cavity enlarges, and a layer is deposited around that already formed. Layer after layer is laid on until the grain attains a full size. This process has been watched by several observers in the fronds of *Hepaticœ*. Crüger, as quoted in the Micrographic Dictionary, says that the unsymmetrical forms of many grains is owing to the differing density of the protoplasm in which they are formed. The thicker part of a grain of potato-starch, for instance, is formed in the thicker protoplasm, while the extended, thinner part is pushed out to where the protoplasm is less dense. It is often said that starch is especially formed in the presence of chlorophyl or the green coloring matter of plants. But we notice that it is generally deposited where there is no chlorophyl, as in the roots, underground stems, the albumen of seeds, etc. Starch is formed in protoplasm, whether there is chlorophyl present or not. When the latter is present, its tendency to collect around the solid matters of the cell, the walls, for instance, will lead it to collect about the forming starch-grain, and thus give that grain the appearance of being embedded in chlorophyl, an appearance often noted.

The form and appearance of the grains differ for each species. In nearly allied species they are much alike; in distant species, very different. Whether in all or most cases specific characters can be drawn from the grains is not fairly settled. It has never been systematically studied, so far as I know. In a few limited cases it has been done and with success. From these it is a fair presumption that specific differences in the grains exist, but are hard to recognize on account of their minuteness.

The size varies much but is tolerably constant for the same species in mature grains. The smallest measured by the writer were only 2 tt.[1] in length. They were from the rhizome of *Hydrastis Canadensis* L. Those measured were the largest grains. On the other hand the grains of potato-starch sometimes reach a length of nearly 50 tt. They are then so large that they can be distinguished by the naked eye. The grains of canna-starch are said to be even larger.

Fig. 156.



Bean Starch.

The commonest starches of commerce are the following. The figures are from Vogl.

1. *Bean-starch* (Fig. 156). The grains are in the cotyledons. They are packed in very closely with aleurone. They are of an ellipsoid or reniform shape, and are 30 tt. or less in length. The rings are usually not visible, though sometimes very evident. The nucleus is long and slit-shaped. In two of the grains figured, smaller cracks can be seen. They are caused by heating. They are easily seen by making a thin section of a bean or by simply

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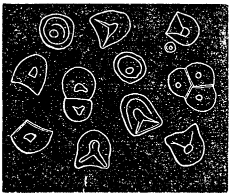
[1] tt = ten thousandths of an inch.

scraping off in a powder a small portion of the cotyledons. They derive their interest, not from their use in the form of starch as food, but because they have formed — or some of the closely allied starches — several almost historical quack medicines, and because they are yet frequently used in Europe to adulterate powdered medicines. The writer has found, in this country, specimens of pearl sago entirely made up of bean or pea-starch.

2. *Potato-starch* has been already figured and partly described. It derives its special interest from its universal use to adulterate powders. Commercial arrowroot, not the proprietary, is, to a considerable extent, made up of potato-starch in this country.

3. *Tapioca* (Fig. 157) is the starch of the root of *Manihot utilissima*, a poisonous Euphorbiaceous plant. The starches of some other closely related species are sometimes intermixed. The grains are small, less than 10 tt. long, shaped like a hemisphere somewhat drawn out. Viewed from the end the grain and nucleus appear round; seen from the side, the grain appears arched, and the nucleus seems to have a conical hollow space extending from it to the base of the arch. In the original condition the grains probably have the truncate ends set together, thus forming compound grains with two individuals in each.

Fig. 157.

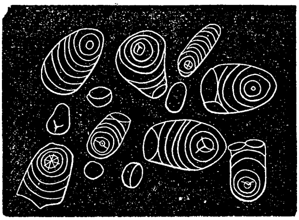


Tapioca Starch.

In commerce, tapioca is in irregularly agglomerated masses of small size and a dead white color. These are formed by heating the grains when wet on hot plates. Sometimes the heat affects the appearance of the starch-grain, swelling it and causing it to bulge out in one or more places.

4. *Sago* (Fig. 158) is from the stem of, probably, several species of palm-trees belonging to the genera *Sagus* and *Saguerus*. It is composed of muller-shaped grains, which are rarely more than 25 tt. long.

Fig. 158.



Sago Starch.

In its original state the starch-grains are compound, consisting of one large grain with one or two quite small ones fastened to it. The component grains are separated in the preparation and we find the small ones scattered among the large. The nucleus of the largest grains is dot-like, eccentric and usually quite distinct. The rings are not very apparent.

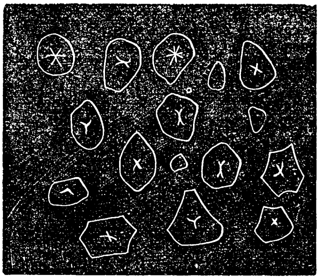
Sago, in American commerce, appears in two forms; common or brown sago, by far the most common, is found in the grocery and drug-stores in small roundish brown masses. They are little altered by heat and the grains present the characters just described.

The pearl sago is in larger spherical balls, of a dead white color. It has been subjected to heat and the grains are smaller and their nuclei are bulged out.

5. *Wheat-starch* consists of disk-shaped grains 16 tt. or less in diameter, mixed with numerous minute spherical grains. The nucleus and rings are usually not visible. Wheat-starch is now not common here as a commercial starch. In medicine and the arts it is nearly replaced by corn-starch.

6. *Corn-starch* is derived from the albumen of the grain of Indian corn. The grains (Fig. 159) are small, from 5 to 10 tt. in diameter, of an irregular form. The surface consists of partly convex, partly flat faces, the latter being formed by mutual pressure of the grains. The nucleus is star-shaped, at least when dry. There are no rings.

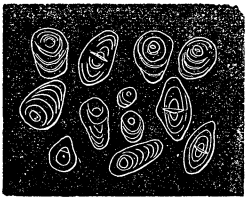
Fig. 159.



Corn Starch.

Corn-starch now replaces the most of the other starches, under its own name or that of maizena, maizone, etc. The *amylum* of the Pharmacopœia which calls for wheat-starch is, in every one of the many samples examined by the writer, corn-starch. As the latter is certainly as palatable as wheat-starch, and is probably more nutritious, we cannot object to the substitution except on the principle that every craft should sail under its own colors.

Fig. 160.



Arrowroot.

7. *Maranta or Arrowroot* is a name applied to a great many starches, the sort being designated by another term, as Brazilian arrowroot, referring to the tapioca-starch when in a powder. West India or Bermuda arrowroot is

the common sort in the United States. It is derived from the rhizome or underground stem of Maranta. It consists of grains (Fig. 161) with a length of 24 tt. or less. They are ellipsoid or egg-shaped with the nucleus in the centre or toward the larger end. By this character it is at once distinguished from Potato-starch, which it otherwise resembles.

The rings are easily seen, though fine. West India Maranta is often adulterated. The starches which are used to falsify it can be detected with certainty only by the microscope.

BOTANICAL OBSERVATIONS IN SOUTHERN UTAH.

BY DR. C. C. PARRY.

No. 5.

No. 143. *Nemacladus ramosissimus* Nutt. Torrey, Bot. Mex. Bound., p. 108, t. 14.

No. 144. *Utricularia vulgaris* L. Cedar City. July.

No. 145. *Phelipœa Ludoviciana* Walp.

No. 146. *Antirrhinum Cooperi* Gray. Proc. Am. Acad., vol. vii, p. 376. A slender twining plant, likely to be overlooked, collected by Dr. Cooper on the Lower Colorado in 1861; also by C. A. Almendinger in 1868; found sparingly near St. George in the shade of high basaltic cliffs. May.

No. 147. *Eunanus* ——? A slender, large flowered, showy annual, growing abundantly on gravelly hills near St. George; flowers mostly bright yellow. A light pink variety (?) was also met with later in the season.

——. *Mimulus rubellus* Gray.

No. 148. *Pentstemon ambiguus* Torrey. Marcy's Rep., t. 16. Dry sandy soil in the upper valley of the Virgen. June.

No. 149. *Pentstemon Eatoni* Gray. Proc. Am. Acad., vol. viii, p. 395. Common in all rocky gorges near St. George; also cultivated in gardens.

No. 150. *Pentstemon glaber* Pursh, var. Cedar City. July.

No. 151. *Pentstemon cæspitosus* Gray, var. Cedar City. July.

No. 152. *Pentstemon puniceus* Gray, var. *Parryi* (?). Beaver-dam mountains. May.

No. 153. *Castilleia parviflora* Bong.

No. 154. *Castilleia affinis* H. & A.

No. 155. *Cordylanthus* (*Hemistegia*) *Parryi*, n. sp. Closely resembling *C. canescens*, from which it is distinguished by its scattered greenish-yellow flowers, the bracts exceeding the calyx and corolla, the narrow erect teeth of the calyx, the tube of the corolla much shorter than the throat, and by the shorter filaments sparsely hairy. *C. canescens* has purple flowers in crowded heads, the bracts equalling the calyx and corolla, the teeth of the calyx short and spreading, the corolla-tube as long as the throat, and all the filaments naked.— Saline marshes in the valley of the Virgen. June. —S. WATSON.

No. 156. *Cordylanthus Kingii* Watson. King's Rep., p. 233, t. 22. High mountains east of Cedar City. July.

No. 157. *Nicotiana attenuata* Torr. Watson, King's Rep., p. 276, t. 27. Common in all waste places near St. George. May.